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Exploring quantum limits with micro-mechanical membranes

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The pursuit of increasingly sensitive interferometric measurement of mechanical motion has a rich history. This pursuit has resulted in the development and study of seminal ideas on quantum limits of measurement and beyond. In recent years, an interesting class of devices has been developed in which low-mass, high-frequency, and mechanically isolated objects are well-coupled to optical cavities. The large response of these mechanical objects to applied forces makes them an ideal platform to observe the effects of radiation forces, which are integral to the physics of quantum limits to interferometric measurement. Some of these nanomechanical resonators have been recently cooled with electromagnetic radiation to near their quantum mechanical ground state, illustrating the capacity for harnessing coherent optical forces. In this talk I present our recent work on a silicon nitride (SiN) membrane coupled to an optical cavity in a cryogenic environment. We use cavity coupling to significantly damp and cool membrane motion, and we demonstrate a low-absorption cavity with an efficient readout. Building on these capabilities, we observe the effect of a fluctuating radiation pressure force on the membrane resonator due to optical shot noise. Continued work will focus on further removing effects of classical noise in our devices; this will provide a path to measurement at the standard quantum limit as well as to using our optomechanical interface for applications in quantum information science. In particular, we are working on devices that will connect disparate quantum resources via SiN membrane resonators with hybrid functionalization.